INTERNATIONAL STANDARD

ISO 12333

First edition
2000-02-01

Aerospace — Constant displacement hydraulic motors — General specifications for 35 000 kPa systems

Aéronautique et espace — Moteurs hydrauliques à cylindrée fixe — Spécifications générales pour circuits 35 000 kPa

Reference number
ISO 12333:2000(E)

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Printed in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 12333 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 10, *Aerospace fluid systems and components*.

Aerospace — Constant displacement hydraulic motors — General specifications for 35 000 kPa systems

1 Scope

This International Standard establishes the general specifications for constant displacement hydraulic motors to be installed in aircraft, which transform hydraulic power into mechanical energy in the form of a rotational torque to 35 000 kPa systems.

Primary and secondary function motors (see clause 3) are covered in this International Standard; actuators with internal rotation angle limits and low-speed motors are not covered in this International Standard.

This International Standard shall be used in conjunction with the detail specification particular to each application.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 2093:1986, *Electroplated coatings of tin — Specification and test methods*.

ISO 2669:1995, *Environmental tests for aircraft equipment — Steady-state acceleration*.

ISO 2671:1982, *Environmental tests for aircraft equipment — Part 3.4 : Acoustic vibration*.

ISO 2685:1998, *Aircraft — Environmental test procedure for airborne equipment — Resistance to fire in designated fire zones*.

ISO 3323:1987, *Aircraft — Hydraulic components — Marking to indicate fluid for which component is approved*.

ISO 3601-1:1988, *Fluid systems — Sealing devices — O-rings — Part 1: Inside diameters, cross-sections, tolerances and size identification code*.

ISO 3601-3:—[1)], *Fluid power systems — O-rings — Part 3: Quality acceptance criteria*.

ISO 6771:1987, *Aerospace — Fluid systems and components — Pressure and temperature classifications*.

ISO 7137:1995, *Aircraft — Environmental conditions and test procedures for airborne equipment*.

ISO 7320:1992, *Aerospace — Couplings, threaded and sealed, for fluid systems — Dimensions*.

1) To be published. (Revision of ISO 3601-3:1987)

ISO 8077:1984, *Aerospace process — Anodic treatment of aluminium alloys — Chromic acid process 20 V DC, undyed coating*.

ISO 8078:1984, *Aerospace process — Anodic treatment of aluminium alloys — Sulfuric acid process, undyed coating*.

ISO 8079:1984, *Aerospace process — Anodic treatment of aluminium alloys — Sulfuric acid process, dyed coating*.

ISO 8081:1985, *Aerospace process — Chemical conversion coating for aluminium alloys — General purpose*.

ISO 8399-1:1998, Aer*ospace — Accessory drives and mounting flanges (Metric series) — Part 1: Design criteria*.

ISO 8399-2:1998, *Aerospace — Accessory drives and mounting flanges (Metric series) — Part 1: Design criteria*.

3 Classification

The hydraulic motors covered by this International Standard are classified in two categories:

— **Category A**: primary function motors, for example flight controls, slats, flaps, adjustable planes, transfer units, constant speed drives, etc.;

— **Category B**: secondary function motors, for example hoists, guns, radars, doors, etc.

The motors category shall be specified in the detail specification.

4 Functional requirements

4.1 Hydraulic fluid

The hydraulic fluid of the system on which the motor is to be installed shall be specified in the detail specification.

4.2 Pressures

4.2.1 Rated supply pressure

This rated supply pressure shall be defined as the system rated pressure.

The rated supply pressure is 35 000 kPa.

4.2.2 Rated differential pressure

The rated differential pressure shall be defined as the differential pressure measured between the motor inlet and outlet ports required to produce rated torque when the motor is at the rated supply pressure.

The rated differential pressure shall be specified in the detail specification.

4.2.3 No-load break-out pressure

The no-load break-out pressure shall be defined as the differential pressure required for starting the output shaft, without interruption, with the drain port at the rated return pressure.

The no-load break-out pressure shall be specified in the detail specification.

4.2.4 Rated case-drain port pressure

The rated case-drain port pressure shall be defined as the maximum pressure at which the motor is required to operate continuously.

The rated case-drain port pressure shall be specified in the detail specification.

4.2.5 Case and return port proof pressure

In order to take into account accidental transitory separation of the components, it is required that the case be designed to withstand, without damage, the pressure resulting from integral bypassing of the rated flow towards the outlet and drain ports. Unless otherwise specified in the detail specification, the case components shall withstand, without damage, an internal pressure at least equal to or greater than 5 000 kPa (50 bar) or 150 % of the maximum pressure specified in the detail specification, whichever is the greater of these two values.

4.2.6 Inlet port proof pressure

Unless otherwise specified in the detail specification, the motor shall statically withstand pressure equal to 52 500 kPa, i.e. 1,5 times nominal pressure, with no structural failure.

In the case of a bi-directional motor, both ports are subject to independent proof pressure surges.

4.2.7 Inlet port burst pressure

Unless otherwise specified in the detail specification, the motor shall statically withstand, once in the life time of the qualification test piece, pressure equal to 87 500 kPa, i.e. 2,5 times nominal pressure, with no structural failure.

In the case of a bi-directional motor, both ports are subject to independent burst pressure surges.

4.3 Rated temperature

The rated temperature of the motor shall be defined as the maximum fluid temperature at the inlet port of the motor; it shall be expressed in degrees Celsius.

The rated temperature is related to the maximum temperature (see ISO 6771) of the hydraulic system in which the motor is to be used and shall be one of the values given in Table 1. The rated temperature shall be specified in the detail specification.

The minimum continuous fluid temperature at the motor inlet port shall be specified in the detail specification.

Table 1 — Temperature relationship

Hydraulic system	Maximum system temperature °C	Rated temperature of motor °C
Type I	70	70
Type II	135	135
Type III	200	200

4.4 Rated displacement

The rated displacement of a motor shall be defined as the maximum theoretical volume of fluid generated by one revolution of its output shaft; it shall be expressed in cubic centimetres per revolution.

The rated displacement shall be calculated from the geometrical configuration of the motor, without allowing for the effects of:

a) permissible manufacturing tolerances;

b) distortions of the motor structure;

c) the compressibility of the hydraulic fluid;

d) internal leakage;

e) temperature.

The rated displacement is used to indicate the sizes of the motor rather than its performance.

4.5 Rated consumption

The rated consumption of a motor shall be defined as the flow rate measured at the inlet port, at rated temperature, rated speed and rated differential pressure.

The rated consumption shall be expressed in cubic decimetres per second and its value shall be specified in the detail specification (with, in parentheses, the corresponding value in cubic decimetres per minute).

4.6 Leakage

4.6.1 Case drain flow

The motor shall provide for case drain flow. The maximum drain flow rate shall be specified in the detail specification with:

a) the motor turning at rated torque and speed;

b) the motor turning at zero torque;

c) the motor stalled, shaft locked at any position.

If required, minimum case drain flow rates shall be specified in the detail specification.

4.6.2 Shaft seal leakage

The maximum shaft seal leakage shall be specified in the detail specification.

4.6.3 External leakage

No leakage from the motor case nor from any case static seal sufficient to form a drop shall be permitted.

4.7 Speed and direction of rotation

4.7.1 Direction of rotation

Unless otherwise specified in the detail specification, the hydraulic motors shall operate satisfactorily in either direction of rotation. It shall not be necessary to alter the motor to effect a change in the direction of rotation, but it should merely be necessary to reverse the direction of flow.

4.7.2 Rated speed

The rated speed of a motor shall be defined as the maximum speed at which the motor is required to operate continuously at rated temperature and at rated differential pressure. The rated speed shall be expressed as the number of revolutions per minute of the motor output shaft.

The rated speed of the motor shall be specified in the detail specification. As an indication, the maximum recommended values are given in the nomograph in Figure 1.

4.7.3 Overspeed

The overspeed value is equal to 115 % of the rated speed.

4.7.4 Maximum no-load speed

The maximum no-load speed shall be defined as the speed reached at rated conditions with no opposing torque.

The maximum no-load speed shall be specified in the detail specification.

4.8 Torque

4.8.1 Rated torque

The rated torque of the motor shall be defined as the minimum torque value at rated operating conditions.

The rated torque shall be specified in the detail specification.

4.8.2 Break-out torque

The break-out torque shall be defined as the minimum torque against which the motor will start at operating conditions specified in the detail specification. The specification shall be met at any angular position of the output shaft.

The break-out torque shall be specified in the detail specification.

4.8.3 Stalling torque

The stalling torque shall be defined as the minimum opposing torque which stops the rotation of the outlet shaft at the rated supply pressure and for outlet port and case-drain port pressures specified in the detail specification.

The stalling torque shall be specified in the detail specification.

4.8.4 Torque pulsations

The motor shall be designated to deliver continuous torque without excessive amplitude ripple (considered as being over ± 10 %) when the motor is operated within the rated speed range at any of the conditions specified in clause 9 as specified in the detail specification.

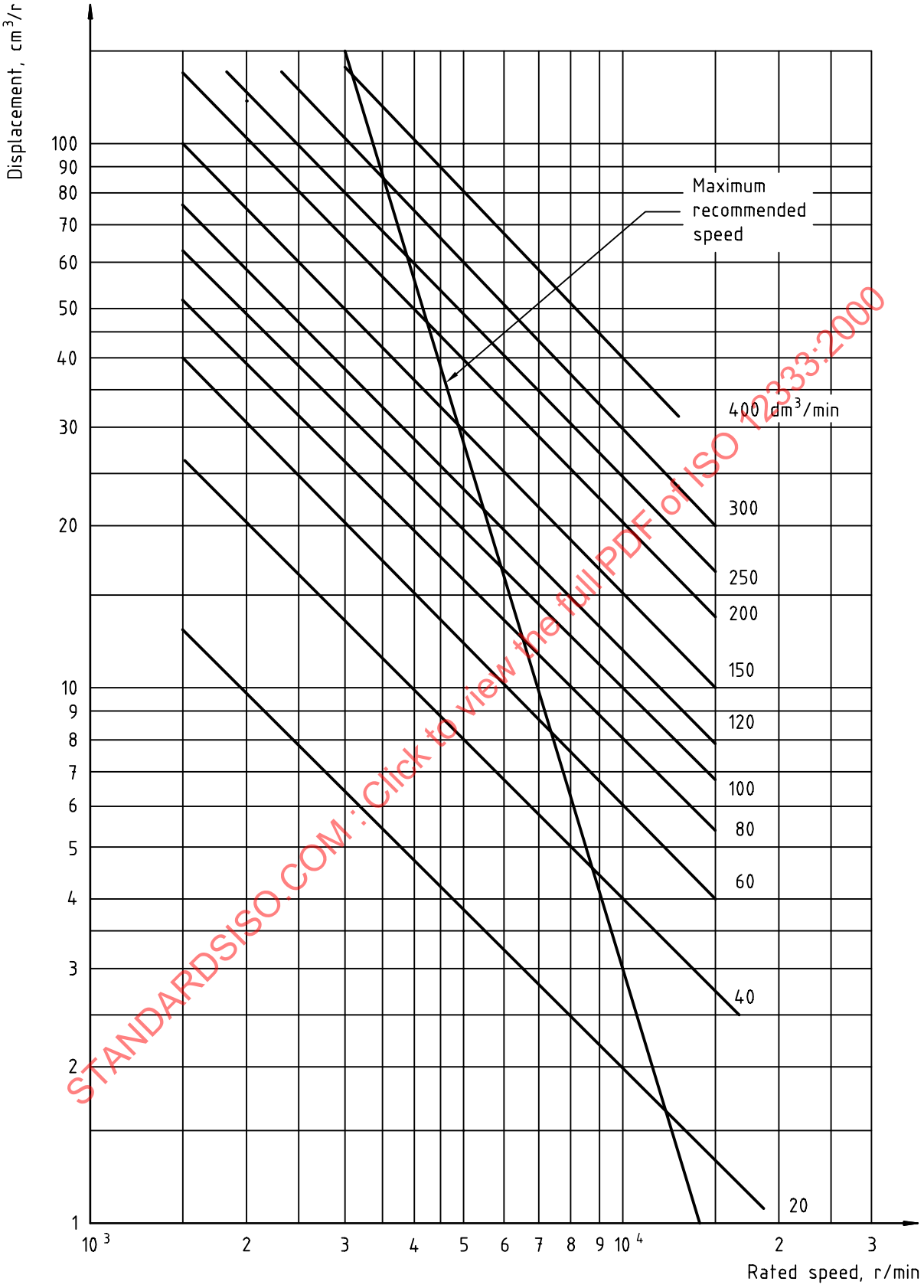

Figure 1 — Nomograph of maximum recommended values for rated speeds against displacement

4.9 Efficiency

The efficiency of a motor shall be defined as the ratio of output power to input power when the motor is operating at rated conditions or any other operating conditions if so specified in the detail specification.

In general it is expressed as a percentage.

NOTE The above ratio is commonly referred to as "overall efficiency" and includes the volumetric efficiency.

The compressibility of the fluid shall be taken into account when calculating the efficiency.

The following efficiency values shall be specified in the detail specification:

a) overall efficiency of the motor when new;

b) overall efficiency of the motor after endurance testing.

4.10 Dynamic characteristics

If requested by the purchaser, the motor polar moment of inertia and motor impedance shall be supplied to assist in developing system dynamic performance.

4.11 Dynamic braking

The motor shall be designed to withstand, at rated conditions, with no operating damage and with no reduction in performance, a braking torque which stops it in 0,02 s.

4.12 Rapid reversals

If required by the application, the motor shall withstand at conditions specified in the detail specification, without damage, rapid reversals of direction of rotation.

4.13 Passive operation

Passive operation of the motor (for example in redundant systems), without fluid supply, shall be specified in the detail specification.

4.14 Noise level

At rated operating conditions, the motor shall have a maximum noise level. If applicable, its value, together with the measuring procedure, shall be specified in the detail specification.

4.15 Rated endurance

If the duration and conditions of the endurance test are not specified in the detail specification, they shall comply with the specifications given in Table 2.

The type of operation shall be specified in the detail specification.

Table 2 — Duration and conditions of the endurance test

Category of motor (see clause 3)	**Hydraulic system** (see Table 1)	**Continuous operation** h	**Operation with alternating load** cycles
A	Types I and II	750	2×10^6
	Type III	250	1×10^6
B	Types I and II		
	Type III	125	$0{,}5 \times 10^6$

5 Installation

5.1 Dimensions

The dimensions required for installing the motor in the aircraft shall be specified in the detail specification.

5.2 Mass

The motor dry mass and mass with hydraulic fluid shall not exceed the values specified in the detail specification.

5.3 Mounting

Unless otherwise specified in the detail specification, all motors shall incorporate a mounting flange in accordance with ISO 8399-1 and ISO 8399-2.

When the mounting flange complies with ISO 8399-1 and ISO 8399-2, the relationship between the maximum displacement of the motor and the type of mounting flange shall be in accordance with Table 3.

Table 3 — Relationship between displacement and flange type

Maximum displacement cm^3/r	Flange type
2,5	150
5	200
10	300
15 20 30 40	350

The installation requirements shall be subject to agreement between the manufacturer and the installer.

5.4 Drive

Unless otherwise specified in the detail specification, an easily removable shaft shall include a shear section between the motor drive shaft and the accessory drive shaft; this shear shaft shall be held in place by means of a positive locking system. The end of the drive shaft shall comply with ISO 8399-1 and ISO 8399-2.

The shear torque, the loads other than those self-induced by the motor torque, and the coupling lubrication mode shall be specified in the detail specification.

5.5 Ports

Unless otherwise specified in the detail specification, the ports shall comply with ISO 7320.

The structure of the ports and the relevant areas of the motor case shall be such that it withstands a torque 2,5 times the maximum torque resulting from attaching or removing the unions and lines on installation or removing motors during maintenance operations; no permanent distortion nor alteration in the correct operation shall occur.

The inlet port corresponding to each direction of rotation, the case drain port, and seal drain port shall be clearly and indelibly marked on each motor.

6 Construction

6.1 Materials

All materials shall be compatible with the hydraulic fluid specified in the detail specification. Materials and processes used in the manufacture of these motors shall be of aerospace quality, suitable for the purpose and shall comply with the applicable official standards. Materials which comply with the motor manufacturer's material specifications are acceptable provided that these specifications are acceptable to the purchaser and include provisions for adequate testing. The use of the motor manufacturer's specifications does not constitute a waiver of other applicable standards.

6.2 Metals

6.2.1 General

All metals shall be compatible with the fluid used and any fluids with which it will be in contact, with the service and storage temperatures, and functional requirements to which the components will be subjected. The metals not in direct contact with the hydraulic fluid shall have the appropriate corrosion-resistant properties or they shall be suitably protected as specified in 6.4.

If the properties or operating safety of the motor are likely to be jeopardized by the use of the materials and processes specified above, other materials and procedures may be used subject to the purchaser's approval.

In this case, materials or processes shall be chosen to provide the maximum corrosion resistance compatible with the operating requirements.

6.2.2 Motors for type I systems

Except for the internal surfaces in constant contact with the hydraulic fluid, ferrous alloys shall have a chromium mass fraction of at least 12 % or shall be suitably protected against corrosion as specified in 6.4. In addition, tin and cadmium platings shall not be used for internal parts or for internal surfaces in contact with the hydraulic fluid or exposed to its vapours. The grooves for external O-rings seals shall not be considered as internal surfaces in constant contact with hydraulic fluid. Magnesium alloys shall not be used.

6.2.3 Motors for type II and type III systems

Ferrous alloys used shall have a chromium mass fraction of no less than 12 % or shall be suitably protected against corrosion as specified in 6.4. In addition, tin and cadmium platings shall not be used for internal parts which are in contact with the hydraulic fluid or exposed to its vapour. Magnesium alloys shall not be used.

6.2.4 Ferrous, copper and aluminium alloys

Ferrous alloys requiring corrosion-preventive treatment and all copper alloys, except for parts with bearing surfaces, shall receive surface plating selected from the following:

a) electrolytic cadmium plating[2];

b) electrolytic chromium plating;

c) electrolytic nickel plating;

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2) See ISO/DIS 8921, *Aerospace — Electroplated cadmium coatings on high-strength steels (maximum tensile strength 1450 to 1850 MPa)*. This project has been withdrawn. Further information can be obtained from Technical Committee TC 20.

d) electrolytic silver plating;

e) electrolytic tin plating, in accordance with ISO 2093;

f) electrodeless nickel plating.

Electrolytic tin or cadmium plating shall not be used for internal parts or internal surfaces in contact with the hydraulic fluid or exposed in its vapours, or on surfaces subjected to abrasion. Where not indicated, the class and type of plating are at the motor manufacturer's discretion.

Moreover, unless otherwise specified in the detail specification, all aluminium alloys shall be protected by anodizing (see ISO 8077, ISO 8078 and ISO 8079); nevertheless, in the absence of abrasive conditions, they can be coated by a chemical film in accordance with ISO 8081.

Exceptions shall be submitted to the purchaser for approval.

6.3 Castings

Castings shall be of aerospace quality, clean, sound and free from cracks, blow holes, excessive porosity and other defects. Defects which do not positively prevent the use of the castings may be repaired at the foundry or during machining by peening, impregnation, welding or other procedures acceptable to the purchaser.

Inspection and repair of castings shall be carried out according to the quality control procedures and standards acceptable to the purchaser.

6.4 Corrosion-preventive treatment

The metals which themselves do not have sufficient corrosion-resistance properties shall be protected in a suitable way in accordance with the specifications laid down in the sub-clauses above so that they can withstand a corrosion which may be due to contact with dissimilar metals, humidity, salt spray or high temperatures.

6.5 Seals

For type I system motors, static and dynamic seals shall, whenever possible, comply with ISO 3601-1 and ISO 3601-3.

For type II system motors, the static and dynamic seals shall comply with ISO 3601-1 and ISO 3601-3.

Seals and back-up rings used for type III system motors shall have been approved by the purchaser.

Subject to the purchaser's approval, non-standard seals may be used to demonstrate compliance with the specifications of this International Standard.

6.6 Lubrication

The hydraulic motor shall be self-lubricated, using only the circulating fluid.

6.7 Balance

The rotating parts of the hydraulic motor shall be inherently balanced in their own right, and the motor shall not vibrate in such a way that any part of the motor or of the driving mechanism breaks throughout the speed range up to the maximum no-load speed.

6.8 Parts with critical installation direction

Parts which are likely to cause incorrect operation or damage if the installation direction is reversed or if they are incorrectly located on assembly shall include mechanical means to prevent them from being installed incorrectly.

6.9 Self-contained failure

The motor shall be designed to completely contain all internal parts in the event of a failure due to an overspeed condition. Maximum overspeed conditions shall be specified in the detail specification. No loss of fluid from the motor shall occur as a result of the failure, other than the external and shaft seal leakages specified in the detail specification.

6.10 Marking

6.10.1 Nameplate

A nameplate shall be securely attached to the motor. The information marked in the spaces provided shall be as specified in the format given in Table 4.

Table 4 — Format for nameplate

Constant-displacement hydraulic motor
Name of manufacturer: .....
Manufacturer's code: .....
Manufacturer's part number: .....
Serial number: .....
Fluid: .....
Displacement: ..... cm^3/r
Rated consumption: ..... dm^3/s (dm^3/min)
Rated pressure: ..... 35 000 kPa
Rated speed: ..... rpm

Any additional data required shall be specified in the detail specification.

6.10.2 Fluid identification

The fluid for which the motor is approved shall be identified in accordance with ISO 3323.

6.11 Seal of guarantee

A manufacturer's non-metallic seal of guarantee shall be used to indicate if the motor has been tampered with internally.

7 Maintainability

7.1 Maintainability features

7.1.1 All wear surfaces shall be replaceable or repairable.

7.1.2 Connections, mounting and wiring provisions shall be designed to prevent incorrect coupling.

7.1.3 In addition to the specifications of 6.8, components which are not functionally interchangeable shall not be physically interchangeable.

7.1.4 The design shall permit line replacement of the unit or module of the unit, using standard tools only.

7.1.5 The design shall be such that special or unique equipment is kept to a strict minimum for shop repair, overhaul and maintenance checks.

7.2 Maintenance concept

The specified maintenance concept shall be specified in the detail specification; for example "On Condition".

7.3 Service life limit and storage specifications

The specifications and appropriate definitions shall be specified in the detail specification and shall include:

a) the time between overhauls (if applicable);

b) the storage life;

c) the service life limit.

8 Reliability

8.1 Equipment compliance

All of the reliability specifications shall be met throughout the service life of the equipment, assuming that all approved maintenance cycles have been carried out.

8.2 Specifications

The specifications and the appropriate definitions shall be specified in the detail specification and shall include.

a) the defect rate;

b) the failure rate;

c) the safety rate (if applicable);

d) the failure mode and effect analysis (FMEA).

9 Quality assurance provisions

9.1 Responsibility for inspection

Unless otherwise specified in the contract or order, the supplier is responsible for carrying out all the inspection operations specified in this International Standard. Unless otherwise specified, the supplier may use his own inspection and testing facilities or the services of any industrial laboratory approved by the national authorities.

The national authorities reserve the right to carry out any of the inspection operations specified in this International Standard where it is deemed necessary to ensure supplies and services which comply with stipulated specifications.

9.2 Classification of tests

For the purposes of checking whether motors the motor comply with this International Standard, the following test programme shall be performed:

a) qualification tests (see clause 10);

b) acceptance tests (see clause 11).

10 Qualification tests

10.1 Purpose

Qualification tests, with the purpose of checking whether motor design is in conformity with the requirements of this International Standard, shall consist of the tests specified in this clause.

10.2 Qualification procedures

10.2.1 Detail specification

The airframe contractor or motor manufacturer shall draw up a detail specification for each motor for which qualification is requested. This specification shall specify compliance with the specifications of this International Standard, including the satisfactory completion of the qualification tests specified. In addition, it shall include any additional requirements to be met and the detail test procedures to be used to ensure satisfactory motor operation and service life in the system concerned. This detail specification shall be submitted to the purchaser for acceptance.

10.2.2 Qualification by analogy

If the following requirements are met:

a) the motor incorporates the same or similar working parts as another motor which has already been qualified by a controlling authority, and

b) the operating conditions are not more restrictive than those for which the other motor has already been qualified,

all or some of the qualification tests may be waived and a report, substantiated by drawings showing the similarity with the already qualified motor, shall be submitted instead of carrying out the tests.

10.2.3 Motor qualification test report

A report of the tests carried out and the test results shall be compiled. This report shall include a full assessment of the extent to which the motors tested comply with the specifications and a detailed account of the way in which the tests were carried out. The report shall also include a description of the instruments used, schematic diagrams and photographs, as appropriate. The complete test results shall be given in the report in table form. Hydraulic test systems shall be described with all the details for each test. Assembly drawings and installation drawings shall be appended to the test report.

10.3 Qualification testing

10.3.1 General conditions

Unless otherwise specified in the detail specification, the pressure, speed, delivery and load parameters shall be maintained to within ± 2 %.

The hydraulic fluid used in all these tests shall be that specified in the detail specification. Unless otherwise specified in the detail specification, the fluid temperature for the test shall be 40 °C ± 5 °C.

The inlet fluid temperature shall be maintained within the following limits:

— for a rated inlet temperature between −55 °C and +45 °C: ± 5 °C

— for a rated inlet temperature between +45 °C and +200 °C: ± 10 °C

The accuracy of the instruments used shall be compatible with the tolerances specified.

10.3.2 Dimensional check

In order to compare the behaviour of critical parts submitted to wear, the dimensions of these parts shall be recorded before and after the qualification tests.

10.3.3 Environmental conditions

The environmental and operating conditions to which the motors are exposed shall be specified in the detail specification, based on the following criteria:

a) temperatures and altitude (in accordance with ISO 7137);

b) humidity (in accordance with ISO 7137);

c) fluids susceptibility (in accordance with ISO 7137);

d) vibrations (in accordance with ISO 7137);

e) acoustic vibrations (in accordance with ISO 2671);

f) steady-state acceleration (in accordance with ISO 2669);

g) resistance to fungus and mould (in accordance with ISO 7137);

h) salt spray (in accordance with ISO 7137);

i) water resistance (in accordance with ISO 7137);

j) sand and dust (in accordance with ISO 7137);

k) shock (in accordance with ISO 7137);

l) fire resistance (in accordance with ISO 2685);

m) ice formation (in accordance with ISO 7137).

10.3.4 Test sequence

The qualification tests are to be carried out preferably in the order given in Table 5 on one or two sample motors (A and B) representative of the motors to be manufactured.

10.3.5 Static proof pressure tests

The static proof pressure tests, intended to test compliance with the specifications of 4.2.5 and 4.2.6, shall be applied once for 5 min.

10.3.6 Static burst pressure test

The static burst pressure test to test compliance with the specifications of 4.2.7 shall be applied once for 15 min. This test should be conducted last since no further operation is specified.

10.3.7 Overspeed test

The performance of the hydraulic motor shall show no evidence of deterioration after it has been running for 30 min at a speed of up to 115 % of the rated speed with a differential pressure as specified in the detail specification.

Table 5 — List and sequence of qualification tests

Tests	Sample			Clause or subclause to be referred to
	A		B	
Acceptance	×		×	11
Dimensional check	×		×	10.3.2
Static proof pressures	×		×	10.3.5
Overspeed	×		×	10.3.7
Operation at overpressure	×		×	10.3.8
Calibration				10.3.9
Torque and flow rates	×		×	10.3.9.2
Dynamic braking	×		×	10.3.9.3
Rapid reversals	×		×	10.3.9.4
Passive operation	×		×	10.3.9.5
Break-out torque	×		×	10.3.9.6
Stalling torque and internal leakage	×		×	10.3.9.7
Low temperature			×	10.3.10
Thermal shock			×	10.3.11
Endurance	×			10.3.12
Endurance in operating reversibility			×	10.3.13
Vibrations			×	10.3.14
Drive shaft shearing	×	or	×	10.3.15
Supplementary tests	×	or	×	10.3.16
Static burst pressure	×	or	×	10.3.6

10.3.8 Operational test at overpressure

The performance of the hydraulic motor shall show no evidence of deterioration after it has been running for 1 min at its rated speed with an inlet pressure equal to 115 % of the rated pressure and with a pressure of 3 500 kPa (35 bar) at the outlet and case drain ports, unless otherwise specified in the detail specification. In the case of a bi-directional motor, the test shall be repeated on the second inlet port.

10.3.9 Calibration

10.3.9.1 General

The calibration test is carried out before and after the endurance test, and comprises the tests described in 10.3.9.2 to 10.3.9.7.

The hydraulic system impedance, the inertia and the stiffness of the opposing load applied to the motor shaft shall be the same as those of the operating conditions specified in the detail specification.

10.3.9.2 Torque and flow rate

Measure the torque produced by the motor and the case inlet and drain flow rates, at a fluid inlet temperature as specified in the detail specification, after operating for at least 5 min at motor rotation speeds of 25 %, 50 %, 75 % and 100 % of rated speed in the following conditions:

— motor outlet and case drain pressures of 200 kPa to 1 400 kPa (2 bar to 14 bar, relative);

— rated motor differential pressure.

The output torque at any of the motor rotation speeds at the above conditions shall not be less than the rated torque. The drain flow rate shall be less than the values specified in the detail specification. The efficiency shall be calculated from the results obtained.

10.3.9.3 Dynamic braking

Install a relief valve set at 115 % of the rated pressure, adapted to the test conditions, on the supply line.

With the motor at rated supply and speed conditions, apply a braking torque to the shaft in order to decelerate continuously from the rated speed to zero within 0,02 s.

The motor shall not be damaged in any way which would jeopardize its subsequent operation.

10.3.9.4 Rapid reversals

This test shall be specified in the detail specification.

10.3.9.5 Passive operation

This test shall be specified in the detail specification.

10.3.9.6 Break-out torque

Measure the break-out torque at the rated supply pressure with the outlet and case leakage pressure values specified in the detail specification.

This torque is obtained using a variable-action brake mounted on the output shaft by gradually reducing the load on the stationary motor.

The measurement shall be taken every 20°; only the minimum value shall be recorded.

10.3.9.7 Stalling torque and internal leakage

Measure the stalling torque at the rated supply pressure, with the outlet port and case drain port pressure values specified in the detail specification, from a specified speed by gradually reducing it until rotation stops by increasing the opposing torque.

The measurement shall be taken at four equispaced, stopped positions. Only the minimum value shall be recorded and it shall be specified in the detail specification.

For each of the measurements, the leakage flow rate shall be less than the specified values.

10.3.10 Low-temperature tests

The hydraulic motor and hydraulic fluid shall be cooled to $-55\ °C \pm 5\ °C$, unless otherwise specified in the detail specification.

The inlet line volume to be cooled shall be specified in the detail specification.

After at least 18 h at the minimum inlet temperature, start the motor with no load and accelerate consistently up to the rated speed.

Repeat the test 50 times.

Then repeat the test 25 times with 110 % of the rated differential pressure and load corresponding to at least the motor rated torque. The capacity of the refrigerating equipment and the length of time between starts shall be such that the motor body temperature and the oil reservoir shall be $-55\ °C \pm 5\ °C$, unless otherwise specified in the detail specification, at each of the 75 starts.

A trace of break-out torque shall be made during the 25 loaded starts.

There shall be no evidence of any deterioration in the motor structure or subsequent operational performance.

10.3.11 Thermal shock test

After maintaining the motor for at least 6 h at a temperature of $-55\ °C \pm 5\ °C$ in the absence of conditions in the detail specification, supply the motor with fluid at a temperature of at least: $+50\ °C$ to the motors type I and $+90\ °C$ to the motors types II and III, and bring up to the rated speed in less than 2 s with a load on the output shaft equal to the rated torque.

Maintain this speed for 5 min.

There shall be no evidence of any deterioration in the motor structure or subsequent operational performance.

10.3.12 Endurance testing

10.3.12.1 General

The requirements for the endurance test programme for motors in continuous operation are given in Table 6 and for motors subjected to alternating loads in Table 7. The endurance time or the number of cycles in operation for the motor category and the type of system are specified in Table 2. The motor under test shall satisfactorily complete the specified endurance test programme with no failure of parts and no excessive wear.

10.3.12.2 Test sample

A sample motor shall successfully complete all the fatigue test related to its category.

10.3.12.3 Hydraulic fluid

The hydraulic fluid used in the endurance test shall be that specified in the detail specification. The test system shall be filled at the start of the endurance test, and no fluid shall be added before the endurance tests are completed, except in the following cases:

a) the amount of fluid unavoidably lost from the system when the filters are checked may be replaced;

b) in the event of damage to the test system away from the motor, resulting in loss or contamination of the fluid not related to the endurance qualities of the motor the system fluid may be completely replaced;

c) in order to maintain the fluid within the physical and chemical property limits drawn up by the purchaser.

A record shall be made of when and how much fluid is added.

10.3.12.4 Leakage permissible during endurance testing

10.3.12.4.1 Case tightness

Throughout the endurance test (including the recalibration time), there shall be no external leakage sufficient to form a drop.

10.3.12.4.2 Shaft seal

When the motor is stopped, the leakage shall not exceed one drop every 2 min. In operation, the leakage shall not exceed 5 cm^3/h.

10.3.12.5 Start-stop tests

Carry out 500 starts and stops at the beginning and end of the endurance test, under the conditions of the first and last phases, respectively.

The test system loading and supply conditions shall be controlled so that motor differential pressure surges of 110 % to 135 % of rated differential pressure occur during each start and stop.

Table 6 — Endurance testing for motors in continuous operation

Test phase	Total duration	Percentage of rated speed	Percentage of rated differential pressure	Case and outlet fluid pressure	Inlet fluid temperature
1[a]	15 min	40 ± 6	50 to 100[b]	Minimum	40 °C ± 5 °C
2	20 min	65 ± 3	50 to 100[b]	1 400 kPa (14 bar), relative	Rated
3	50 min	85 ± 2		Minimum	
4	20 min	100 ± 2		700 kPa (7 bar), relative	
5	15 min	20 ± 2		3 400 kPa (34 bar), relative	
6[a]	20 min	110 ± 2	60 to 100[b]	Minimum	

[a] See 10.3.12.5.

[b]
- Each phase begins with a test at 50 % of rated differential pressure.
- For each phase, the operating period at 100 % of rated differential pressure last for 5 min.
- The transition from one period to the other shall take place in less than 1 s.
- Each 125-h interval corresponds to 50 series of the 6 phases described.

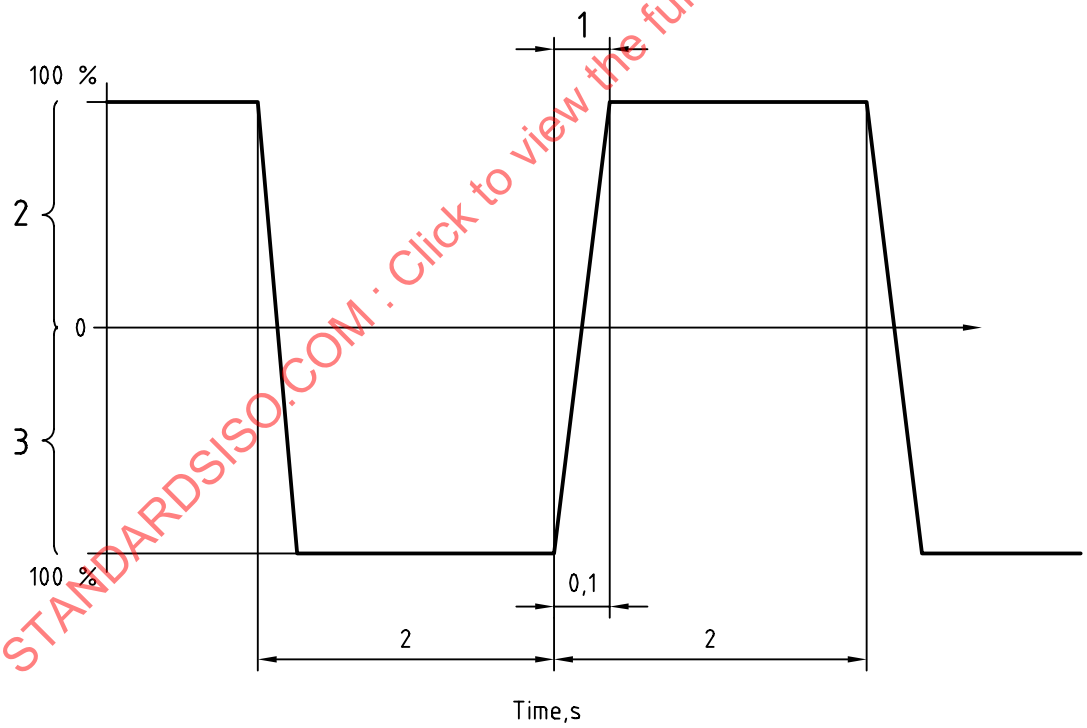
Table 7 — Endurance testing — Alternating load

Test phase	Percentage of total number of cycles	Input signal	Frequency cycles/s	Percentage of rated speed	Percentage of corresponding load at rated torque [a]	Case and outlet fluid pressure [b]	Inlet fluid temperature
1	25	See Figure 2	0,25	100 ± 2	50	400 kPa to 700 kPa (4 bar to 7 bar)	40 °C ± 5 °C
2	37,5	Sine wave[c]		25 ± 2	20		70 °C ± 5 °C
3	5		3	50 ± 2	40	500 kPa to 1 000 kPa (5 bar to 10 bar)	Rated
4	5			100 ± 2	80		
5	10			25 ± 2			
6	12,6		5	10 ± 2	25		
7	5		3	50 ± 2	45		

[a] Load is driving on a half-sine wave.

[b] The inlet, outlet and case pressure values shall be indicated for servo-controlled motors.

[c] The sine wave shall be positive in the clockwise direction and negative in the counter-clockwise direction, and shall pass through 0 r/min.



Key

1 90 % of speed change shall be within this time interval

2 Clockwise

3 Counter clockwise

Figure 2 — Square-wave speed-cycle test